NEW STRAIGHTNESS AND
CALCULATOR OPTIONS

5526A LASER MEASUREMENT SYSTEM

HEWLETT hp PACKARD

INTRODUCTION

The Hewlett-Packard Laser Measurement System is a major advance in economical interferometry since a single laser source can make a wide range of measurements. Remote interferometers are available to measure LENGTH, ANGLE, FLATNESS, STRAIGHTNESS, and SQUARENESS. In addition, a TWO-CHANNEL laser head is standard so two measurements may be made simultaneously. Linear displacement measurement is not restricted to cube-corner retroflectors—practical PLANE-MIRROR reflection is just one more alternative in this unique dimensional metrology system.

However, these advanced features do not restrict the system to the metrology lab. Every part of the Model 5526A has been designed for the machine shop. The laser is a rugged module with an expected life well in excess of 10,000 hours. Optical components are mounted in sealed, stainless steel housings with easy-to-clean windows. Operation is extremely simple, with instant warm-up and totally automatic tuning and error sensing.

With the HP Laser Measurement System calibrations of machine tools and measuring machines can be accomplished with speed, accuracy and simplicity without the need for several instruments. For example, a multi-axis N/C machine tool or coordinate measuring machine can be checked out by one man in less than a day for positioning accuracy, pitch and yaw motions, bed flatness, straightness of travel (alignment), and squareness of axes—with a printed or plotted record of each measurement. Surface plates can be calibrated in a fraction of the time previously required. Other calibrations which can be made with the Model 5526A include scales, gages, micrometers, leadscrews, rotary tables and straightedges.

The two-channel laser head combined with remote optics makes built-in applications attractive, either for read-out or feedback control.

Applications outside the metalworking industries include integrated circuit manufacturing, computer memory disk systems, photogrammetry, dilatometry, optical manufacturing and physical research. The two-frequency AC principle, unique to Hewlett-Packard even makes it possible to measure displacements at large distances. Structural oscillations have been recorded at distances in excess of 700 feet (210m).

LASER MEASUREMENT SYSTEM

The significant feature of this system is total modularity. This enables you to solve almost any dimensional metrology problem with the most economical investment. And when your measurement needs grow additional capability can be added at relatively low cost.

This modularity is achieved by separating the laser from the interferometer optics. The Laser Measurement System follows a building-block approach with the 5526A Laser/Display at the base and a set of Interferometer options to choose from as needed. Interferometers available at this time include Linear Displacement, Linear + Angular/Flatness, Straightness/Squareness and Single Beam Linear Displacement. Add-on options allow conversion from one type to another plus the addition of a second measurement axis since the standard Laser Head can make two measurements simultaneously.

Owners of earlier model HP Laser Interferometers are not neglected. All 5526A Interferometer Options can be used with Model 5525B Laser Interferometers.

5526A LASER/DISPLAY

All configurations of the Laser Measurement System must include the 5526A Laser/Display, which is comprised of the 5500C Laser Head and the 5505A Laser Display.

5500C LASER HEAD

The core of the system is the unique two-frequency gas laser developed and manufactured by Hewlett-Packard. Fully automatic tuning and instant warm-up combined with a remote interferometer assure drift-free accuracy from the instant of switch-on. And the two-frequency principle means that fully 95% of the beam can be lost before the error trip is triggered. The laser tube has proven its tremendous reliability with the many hundreds of 5525A/B Laser Interferometers now in use, and a tube lifetime in excess of 10,000 hours can confidently be expected. If replacement should be necessary, a new tube can be installed simply and quickly in the field without special instruments or training.

A solid-state frequency tuning device assures very high reliability and frequency stability.

Since there is no interferometer in the 5500C Laser Head, all users benefit from the advantages of remote interferometry without the additional cost of an internal interferometer. However, the remote interferometer modules may be attached to the Laser Head if required.

Another significant feature is that of two channels in a single head. Two sets of measurements, or two axes of a machine tool or measuring machine, may be monitored simultaneously by the addition of a Beam Splitter, a second interferometer and a second Laser Display. This feature opens up many more calibration, read-out and closed-loop control applications.

5505A LASER DISPLAY

This compact module is a high speed counter, calculator, digital read-out and multi-purpose interface device. Measurements are displayed by a 9-digit display with plus-minus sign and automatic decimal point indication. Four operating modes are included in the standard instrument: NORMAL, SMOOTH, X10 and VEL. NORMAL gives a resolution of 0.000,01 inch (0.1 μm) or 1 arc-second with a very high update rate, useful where it is required to follow rapid motion or to provide feedback for closed-loop systems. SMOOTH has the same resolution but averages many readings to give jitter-free display in a vibrating environment. X10 reads to 0.000,001 inch (0.01 μm) or 0.1 arc-second and is also smoothed. The VEL mode displays the velocity of the displacement being measured.

A unique feature of the 5505A is the facility to switch from one type of units to another without losing measurement information. Linear displacements, including straightness and flatness can be read out in inch, millimeter or quarter-wavelength units. Angular measurements are read out directly in arc-seconds.

Compensation for air refractive index changes requires the dialing in of a correction factor which is determined from a table provided with the operating literature. To reduce set-up time and increase accuracy in uncontrolled environments, the 5510A Automatic Compensator offers accurate, continuous and readily verifiable compensation. See page 14 for details.

Measurement data is available at the Laser Display rear panel in BCD form. This makes for easy interfacing to a wide variety of recording, controlling and computing devices, many of which are available from Hewlett-Packard as options to the Laser Measurement System. Additional output formats optionally available include analog for real-time error plotting or strip chart recording, fringe-based up-down pulse or quadrature signals, and the reference and Doppler frequency signals taken directly from the Laser Head output.

SPECIFICATIONS

The following are general specifications which apply to all types of measurement made with the 5526A Laser/Display. Specifications which pertain to specific interferometers are contained in the Interferometer Option sections.

PERFORMANCE

LASER: Helium-Neon type with Zeeman-split beam. Zero warm-up time. Fully automatic tuning.

ACCURACY: (for all linear displacement measurements)
Inch units: ±0.5 parts per million ±1 count in last digit
Metric units: ±0.5 parts per million ±2 counts in last digit

RESOLUTION:
Normal and Smooth Modes:
Inch: 0.000,01 inch
Metric: 0,1 micrometer
Angular: 1 arc-second
X10 Mode:
Inch: 0.000,001 inch
Metric: 0,01 micrometer
Angular: 0.1 arc-second
With Option 003 Resolution Extender an additional digit can be resolved in all modes of operation.

MAXIMUM ALLOWABLE SIGNAL LOSS: 95% (-13 dB)

MAXIMUM LATERAL OFFSET OF RETURN BEAMS: ±0.2 inch (±5 mm). The remote interferometer or the cube-corner retroreflector may be offset by a maximum of ±0.1 inch (±2,5 mm) since the reflected beam is displaced by twice the cube-corner displacement.

MAXIMUM MEASURING VELOCITY: 720 in/min (0,3m/sec)

VELOCITY MEASUREMENT ACCURACY: ±0.01 in/min (±4,0 micrometers/sec)

ATMOSPHERIC AND MATERIAL TEMPERATURE COMPENSATION: Manual input from tables supplied. Automatic compensation optional.

OPERATING

DISPLAY: 9 digits with appropriate decimal point, commas and + or - sign. Nonsignificant leading zeros are blanked.

UNITS:
Distance Modes: inches, millimeters, λ/4
Velocity Mode: inches/second, inches/minute, mm/second, mm/minute

DISPLAY OVERFLOWS:
Normal and Smooth Modes: 3,100 inches (258 feet); 79,000 mm (79m); 500,000,000 λ/4
X10 Mode: 620 inches (51 feet); 10,000 mm (10m); 100,000,000 λ/4

ERROR INDICATION: Beam interruption, overspeed and tuning error. Display goes to zero and light flashes.

RESET: Pushbutton reset to zero.

TEST CIRCUITS: Front panel, pushbutton operated test circuits verify that all counting and computing circuits are operating properly.

INPUTS: Automatic velocity of light compensation or remote manual VOL compensation.
Connector: 50-pin Amphenol Blue Ribbon
Auxiliary: Remote front panel controls, i.e., Reset, Manual, Print, Normal, Smooth, X10, Velocity, Tuning Error, Beam Interrupt Error.
Connector: 24-pin Amphenol Blue Ribbon

OUTPUTS: 1, 2, 4, 8 positive true BCD output for printer, computer, Fourier Analyzer, etc.
Connector: 50-pin Amphenol Blue Ribbon
Analog output with Error Plotting options.
Connector: 2 BNC types
Timed contact closure for automatic NC test advance, or periodic data recording applications.
Connector: Dual banana

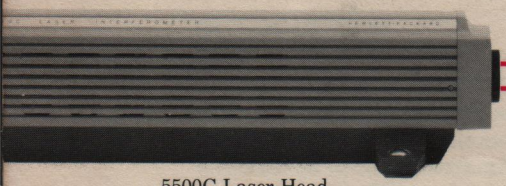
AUTO TIMED PRINT AND/OR AUTO N/C ADVANCE: Contact Closure Rate: 6—100 accurately timed points/NC steps per minute.

ENVIRONMENTAL (Operating):
Temperature: 32° to 130°F (0° to 55°C)
Relative Humidity: 0 to 95%
Vibration: Tested to withstand 0.010 inch (0,25 mm) peak-to-peak excursion at 10—55 Hz 15 min. on each of 3 orthogonal axes.

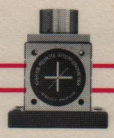
POWER REQUIREMENTS: 115 to 230 volts ±10%; 50—60 Hz, 150W.

OVERALL DIMENSIONS:
Display: 5.53 in. high x 16.75 in. wide x 13.25 in. deep (141 mm x 436 mm x 337 mm)
Head: 5.00 in. high x 7.00 in. wide x 20.70 in. long (127 mm x 178 mm x 526 mm)

WEIGHT:
Laser Display: 24 lb (10,9 Kg)
Laser Head: 17 lb (7,8 Kg)



5500C Laser Head



Remote Interferometer

INTERFEROMETER OPTIONS

The Model 5526A Laser/Display does not include an interferometer. To make any measurement one or more must be selected from the following set:

Option 10: Linear Interferometer
Option 12: Plane Mirror Interferometer (Conversion Kit)
Option 20: Linear + Angular/Flatness Interferometer
Option 30: Straightness Interferometer
Option 40: Single Beam Interferometer

For two-axis installations all the additional items required are included in two Add-On Options:

Option 11: Second Axis Add-On
Option 13: Second Axis Add-On (Plane Mirror)

To upgrade the Option 10 Linear Interferometer to make Angular and Flatness measurements requires the addition of a single option: Option 21: Angular/Flatness Add-On.

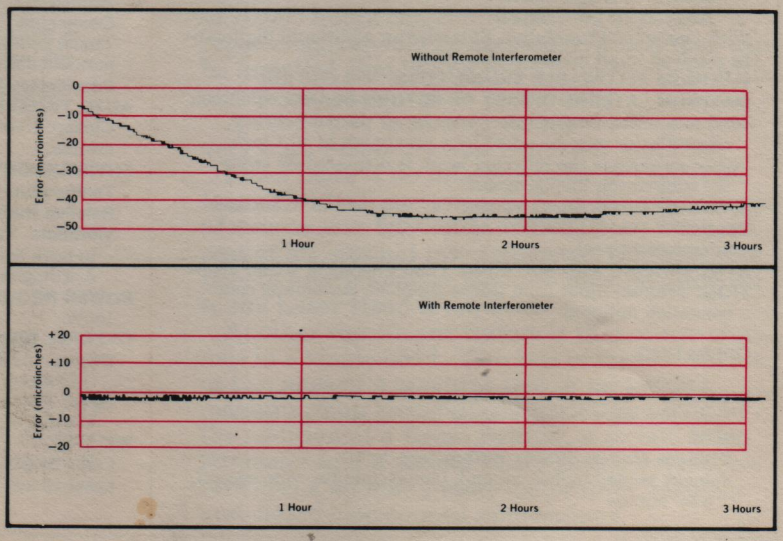
Although current at the time of printing, the above list may be expanded at any time as a result of Hewlett-Packard's ongoing development program. Contact your nearest HP office for the latest information on new products.

LINEAR MEASUREMENT
Option 10: Linear Interferometer

This completely passive, multi-purpose interferometer (the "Magic Cube") makes for an almost perfect linear measuring instrument. Although it may be attached to the laser head, it offers significant advantages when used remotely. Complete thermal stability is assured since the laser head can be some distance away on a tripod. The small size of the remote interferometer makes for easy fixturing and minimal distortion of the measurement set-up. Deadpath can be virtually eliminated, not just partially corrected, because the interferometer may be mounted very close to the zero datum point of a measurement. Permanent installation of the interferometer in machine tools or measuring machines is considerably simpler, and is thus more easily justifiable than for other laser interferometers. Additional accessories convert the Magic Cube into an interferometer for measuring angles or displacement of plane mirrors.

The cube-corner retroreflector is mounted in a small housing for maximum mounting flexibility which is in turn mounted on an adjustable mounting stand.

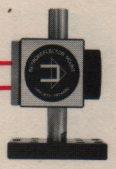
With the remote interferometer mounted either internally or externally, setup and alignment is a simple matter since the maximum allowable lateral deviation of the returning beam is at least ±0.1 inch (±2.5 millimeters).



REMOTE INTERFEROMETRY ENSURES HIGH STABILITY, HIGH ACCURACY

The graphs show the dramatic increase in measurement stability resulting from the elimination of heat sources from the interferometer. Since the 5500C Laser Head has no internal interferometer all 5526A Laser Measurement Systems use a remote interferometer.

Remote Interferometer



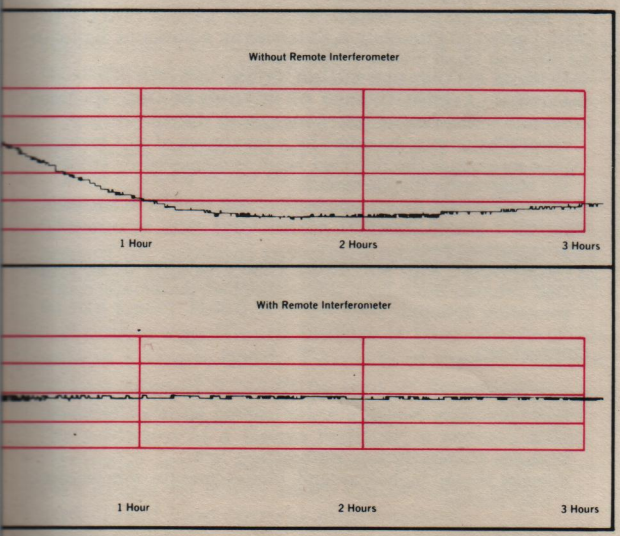
Retroreflector

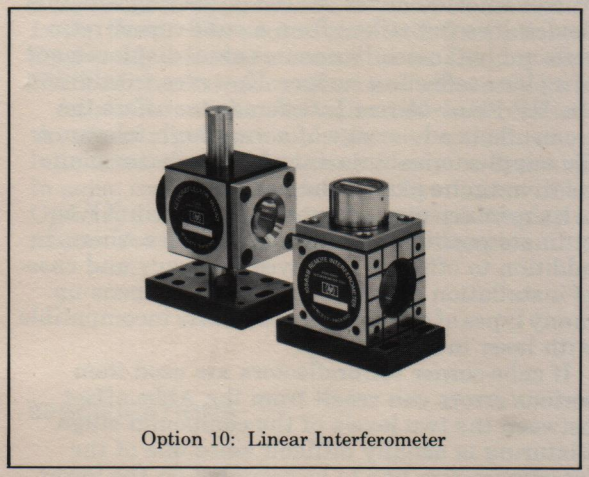
LINEAR MEASUREMENT
Option 10: Linear Interferometer

This completely passive, multi-purpose interferometer (the "Magic Cube") makes for an almost perfect linear measuring instrument. Although it may be attached to the laser head, it offers significant advantages when used remotely. Complete thermal stability is assured since the laser head can be some distance away on a tripod. The small size of the remote interferometer makes for easy fixturing and minimal distortion of the measurement set-up. Deadpath can be virtually eliminated, not just partially corrected, because the interferometer may be mounted very close to the zero datum point of a measurement. Permanent installation of the interferometer in machine tools or measuring machines is considerably simpler, and is thus more easily justifiable than for other laser interferometers. Additional accessories convert the Magic Cube into an interferometer for measuring angles or displacement of plane mirrors.

The cube-corner retroreflector is mounted in a small housing for maximum mounting flexibility which is in turn mounted on an adjustable mounting stand.

With the remote interferometer mounted either internally or externally, setup and alignment is a simple matter since the maximum allowable lateral deviation of the returning beam is at least ±0.1 inch (±2.5 millimeters).





Option 10: Linear Interferometer

SPECIFICATIONS

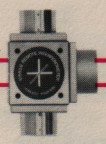
Specifications of the Model 5526A Laser/Display apply with the following additions:

RANGE: Up to 200 feet, depending on conditions; greater range can be obtained by means of an internal adjustment.

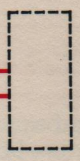
BEAM ALIGNMENT: Exit beam parallel to incoming beam to within ±30 arc-seconds. Reflected beam perpendicular to exit beam to within ±30 arc-seconds provided exit beam is perpendicular to exit face.

DIMENSIONS: See back page.

WEIGHT: 10565B Remote Interferometer: 2.7 lb (1,1 Kg)
10550B Reflector and Mount: 2.0 lb (0,8 Kg)



Plane Mirror Interferometer



Plane Mirror

PLANE MIRROR MEASUREMENT
Option 12: Plane Mirror Conversion Kit
Option 13: Second Axis Add-On (Plane Mirror)

The 5526A Option 12 is an Add-On Kit which converts an HP Linear Interferometer to a Plane Mirror Interferometer. As the name suggests this device does not reflect from a cube-corner retroreflector but instead measures axial displacement of a plane reflecting surface. However, in addition the HP Plane Mirror Interferometer offers the tremendous advantage of a very high tolerance for angular misalignment of the reflector plane relative to the axis of the beam.

Its primary area of application lies in XY coordinate positioning tables and stages where, in addition to offering improved accuracy and ease-of-installation over other methods, it opens up many types of application previously incompatible with laser interferometry.

If cube-corner retroreflectors are used then serious errors can result from the Abbe offset between the two levels of the compound stage. Fixturing is usually difficult since one of the interferometers has to be mounted on the lower moving stage. In addition, a number of beam bends are generally required to direct the light beams to the right levels in the right directions.

These problems are avoided with two continuous reflectors mounted orthogonally on two edges of the table, in the same horizontal plane. Roof prisms are an example of such a reflector but are expensive and highly sensitive to just a few arc-seconds of yaw or roll motion of the table during translation. Thus their use is restricted to small, very precise stages.

In contrast the HP Plane Mirror Interferometer uses relatively inexpensive plane mirrors and can tolerate many *arc-minutes* of angular misalignment. The only constraint is that enough light return to the receiving aperture at the Laser Head. Since 95% of the return signal may be lost without effect there is no reason why the system cannot be installed on large, poor quality tables where 10X or even 100X improvement in accuracy may be readily obtained compared with non-interferometric methods. Areas of application include read-out and control in IC mask-making, jig grinding and boring, coordinate measuring machines, toolmakers' microscopes, photogrammetry and artwork generation.

An additional feature of the HP Laser Measurement System which enhances its attractiveness for such applications is the two-channel Laser Head. The second-axis Add-On Option, Option 13, includes a second Laser Display and Plane Mirror Interferometer, and a Beam Splitter.

As a result of the two reflections inherent in the plane mirror principle there is optical resolution doubling. Although this may be desirable in some cases the standard configurations of Option 12 and 13 includes a modified Display to restore the read-out to its correct resolution.

SPECIFICATIONS

PERFORMANCE: As for the Model 5526A Laser/Display and Option 10 Linear Interferometer

REFLECTOR REQUIREMENTS:

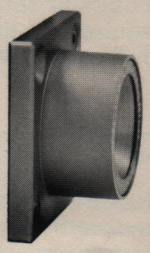
Flatness: Must not deviate by more than $\lambda/8$ (3 microinches) over any 0.8 inch (20 mm) dimension.

Surface Finish: Metal 0.1—0.3 microinch arithmetic average
Optical 80 — 40.

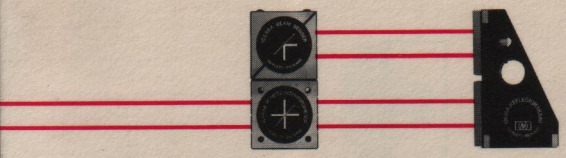
Maximum Angular Misalignment: Depends on distance between interferometer and mirror plane. Typical values are:
±25 arc-minutes for 10 in. (254 mm)
±15 arc-minutes for 20 in. (508 mm)
± 5 arc-minutes for 50 in. (1270 mm)

DIMENSIONS: See back page.

WEIGHT (Option 12): 10581A, 0.5 lb (0,22 Kg)



Plane Mirror Converter



Angular Interferometer

Angular Reflector

ANGLE AND FLATNESS MEASUREMENT
Option 20: Linear + Angular/Flatness Interferometer
Option 21: Angular/Flatness Add-On

The "Magic Cube" Remote Interferometer has the very convenient feature that the reference reflector can be detached, enabling differential measurements to be made. By substituting a 45° mirror (10558A Beam Bender) for the cube-corner reflector the reference beam is deflected forward parallel to the main measurement beam. With two cube-corner reflectors located in a special mount (10559A Reflector Mount), such that their spacing matches that of the two parallel beams, it is possible to make interferometric measurements of angles. Thus the same instrument which was used to check positioning accuracy of a machine tool or measuring machine can be used to check for pitch and yaw motions. In addition the dual reflector mount has feet machined onto it so that fast, accurate calibrations of surface plate flatness may also be made with the same instrument.

Option 20 includes the optical modules for both linear and angular/flatness measurements. Option 21 provides the items necessary to upgrade the Option 10 Linear Interferometer to Option 20. This add-on option includes the following:

10558A Beam Bender
10559A Reflector Mount
10557A Turning Mirrors (2 each)

The turning mirrors are designed especially for rapid surface plate calibration by deflecting the measuring beams to the various calibration lines with only a single set-up of the Laser Head.

Basic resolution is 0.1 arc-second and is read-out directly with the Laser Display in the Inch mode, with 1 micro-inch corresponding to 0.1 arc-second. Maximum angular range is ±10 degrees, with corrections required for angular displacements greater than 50 minutes.

FLATNESS

The HP Laser Measurement System offers many advantages over autocollimators and levels for calibrating the flatness of surface plates and machine tool beds. Most significantly it reduces the time required by 50% or more. In addition, it improves both the repeatability and the accuracy of readings. Since the Laser Head is mounted off the table on a tripod, potentially serious distortions due to the heat and mass of an autocollimator mounted on the surface plate are avoided.

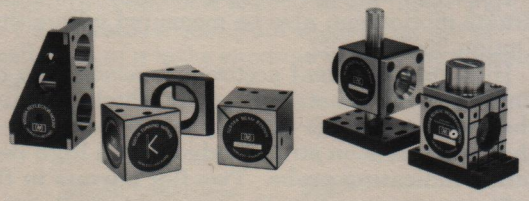
The reflector mount has feet which are spaced to give a direct read-out of elevation difference, in inches or millimeters, eliminating one of the calculations required to produce deviations from a mean plane. Data can be rapidly recorded on a printer during the calibration or, to increase overall time-savings even more significantly, can be fed directly into an HP calculator for automatic computation.

PITCH AND YAW

Unwanted angular motions can cause Abbe offset errors of potentially greater magnitude than lead errors. It is, therefore, important, when certifying a machine tool or measuring machine, to measure pitch and yaw motions.

The HP Laser Measurement System can check both for errors of position *and* for pitch and yaw components of motion of the table or column. Large machines can be calibrated just as easily as small ones since angular measurements can be made at ranges of up to 200 feet (60m), depending on conditions.

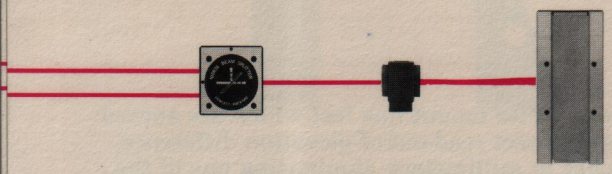
Readings are in arc-seconds and can be printed, plotted or recorded on tape for subsequent analysis. Since the Laser Head has a second channel it is possible to measure both angle and length simultaneously. Thus a graph of pitch or yaw versus distance may be plotted as the calibration traverse is being made.



Option 20: Linear + Angular/Flatness Interferometer

SPECIFICATIONS

ANGLE:
Resolution: (X10 Mode, Inch units selected): 0.1 arc-second (0.01 arc-second with 5526A Option 004 Resolution Extender)
Accuracy: ±0.1 arc-second ±1 count in last digit up to ±100 arc-seconds; ±1 arc-second ±1 count in last digit up to ±1000 arc-seconds; ±4 arc-seconds per degree ±1 count in last digit up to ±10 degrees using correction formula.
FLATNESS: Resolution and Accuracy are the same as for linear measurement because the foot-spacing of the 10559A Reflector Mount matches that of the cube-corner spacing.
DIMENSIONS: See back page.
WEIGHTS: 10558A: 1.5 lb (680 gm)
10559A: 2.2 lb (990 gm)
10557A: 1.0 lb (450 gm)



Straightness Adaptor | Straightness Interferometer | Straightness Reflector

STRAIGHTNESS AND SQUARENESS MEASUREMENT

Option 30: Straightness Interferometer (Short Range)
Option 31: Straightness Interferometer (Long Range)
Option 32: Straightness Interferometer (Full Range)
Option 33: Pentaprism

The HP Straightness Interferometer is a highly accurate straightedge which is capable of measuring the straightness of machine tool and measuring machine coordinate motions with interferometric accuracy over a range of up to 100 feet (30 m). More accurate and far less sensitive to air turbulence than alignment lasers, the novel HP system is compact enough to be carried in a small case and to be mounted on the smallest machines. As well as determining straightness, the same hardware can measure squareness and parallelism. The Option 33 Pentaprism extends the "straightedge" through a precise 90-degree bend, permitting the measurement of perpendicularity on all types and sizes of machine tools and measuring machines. Parallelism between the spindle axis and a coordinate motion can also be measured with either Option 30, 31, or 32.

High measurement accuracy is assured by the unique interferometric principle which, despite the use of a laser, is actually much more like that of a precision straightedge with a high resolution indicating probe. Two flat mirrors in the reflector, representing the "straightedge", are scanned by two divergent beams exiting from the Interferometer as it is moved relative to the Reflector. Out-of-straightness is read out directly in inches or millimeters by the same Laser Display that is used for linear measurements.

Computing and recording of the geometric characteristics of the machine being calibrated are facilitated by an optional Calculator/Plotter system which accepts measurement data directly from the Laser Display. Specially developed metrology and machine tool calibration programs are included with this system (5526A Option 200 series).

SELECT HIGH RESOLUTION OR LONG RANGE

If your measurement requirements call for a 10 ft. (3 m) long straightedge with a resolution of a microinch (0.01 μm) then the Short Range version of the Straightness Interferometer (Option 30) should be your choice. However, if your straightness measurement range is greater, then the Option 31 Long-Range version will meet your needs from 3 ft. out to 100 ft. (1 — 30 m). The resolution of this version is 10 microinches (0.1 μm).

For requirements covering the full range, Option 32 includes short and long-range interferometers. In this option the Model 10579A Straightness Adapter is shared between both versions.

The difference between long and short-range versions lies in the Interferometer and Reflector, both of which comprise a matched pair. Externally, the two versions are the same; however, the beams exit from the long-range interferometer at one-tenth the divergence angle of the short-range version.

MEASURES PARALLELISM AND PERPENDICULARITY

The geometry of a machine tool or measuring machine is just as important as the errors in any individual coordinate motion. The HP Straightness Interferometer has been designed to make total calibrations of coordinate geometry systems, including parallelism and perpendicularity. For instance, the degree of parallelism between a spindle axis and a coordinate motion can easily be measured by mounting the Straightness Reflector in the spindle and rotating it through 180 degrees between straightness calibrations. Out-of-parallelism is then given by half the angle between the resultant best-fit mean lines. Figure 1 illustrates a set-up for measuring out-of-parallelism of a lathe carriage axis to the spindle center-line.

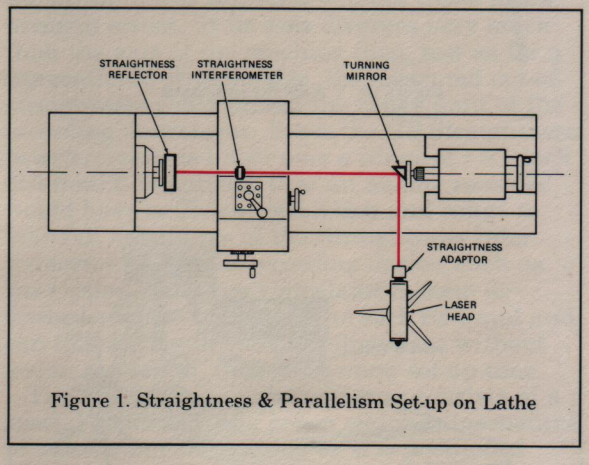


Figure 1. Straightness & Parallelism Set-up on Lathe

Perpendicularity is measured by adding an accurate right-angle bend to the "straightedge" (the centerline of the Straightness Reflector). The Option 33 Pentaprism accomplishes this optically by enabling the laser beam to "see" the Reflector through ninety degrees.

Figure 2 shows such an arrangement, measuring the out-of-straightness in the X and Y-axes of a planer-milling machine. In this case the Straightness Reflector is mounted on the table with its axis aligned with the Y-axis and the Straightness Interferometer located in the spindle. The laser beam is directed from the position shown in Figure 2(a), for Y-axis straightness measurement. By adding a ninety-degree bend to the axis of the Reflector with the Pentaprism, and relocating the laser to the position shown in Figure 2(b), out-of-straightness in the X-axis is measured. A comparison of the slopes of the mean lines yields out-of-squareness.

Since the axis of the Reflector beam is the straightness reference, **not** the laser beam, the Laser Head can be mounted on a tripod, such as the 10580A Laser Tripod, at some convenient location. Thus, set-ups can be made conveniently and quickly in your shop or lab.

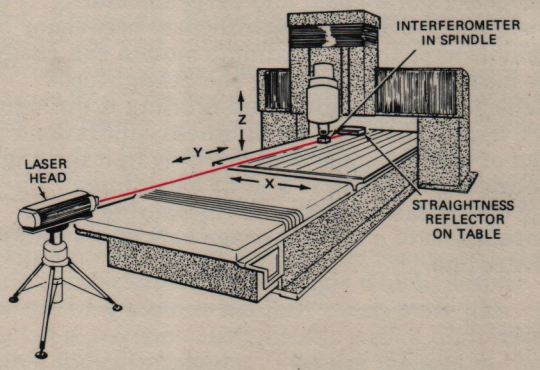


Figure 2a. Y-Axis Straightness

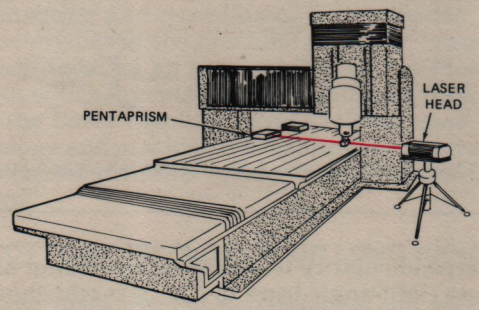
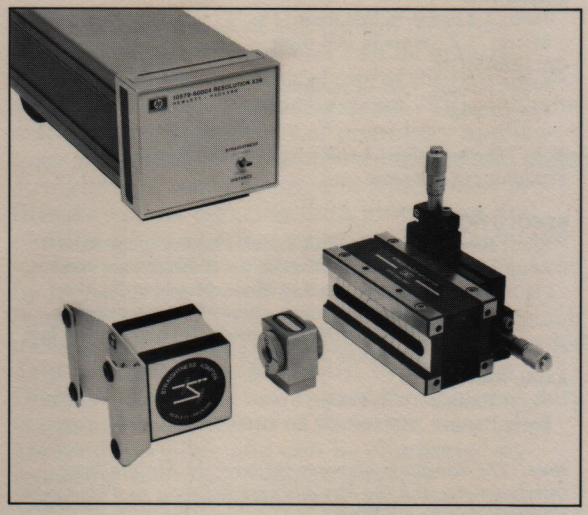


Figure 2b. X-Axis Straightness

SET-UP

Since the laser beam has to pass through the Straightness Interferometer to the Straightness Reflector and back again to the detector in the Laser Head, it is important to set up and align the system correctly. However, individual components of the system have been designed to make alignment as easy as possible, and typical alignments can be accomplished in no more than five or ten minutes.



The Straightness Reflector is equipped with a kinematic mounting plate which has two micrometer adjustment screws. This permits the user to precisely align the reflector axis, which is the "straightedge" of the system, with the coordinate axis being calibrated. A ground shaft is provided for fixturing in a spindle or in a vee-block. Alternatively it can be clamped directly to a table.

It should be emphasized that misalignment of the Straightness Reflector will not cause measurement errors. If its axis diverges very much from the axis of the machine then, just as for a conventional straightedge, the measured out-of-straightness could exceed the range limit of the recording instrument. Since the HP Straightness Interferometer is linear over a range of ± 0.1 inch (2.5 mm) it is unlikely that an analog recorder would have sufficient resolution and range to take full advantage of the Straightness Interferometer. A digital recording device, such as the Option 200 series Calculator System described on page 14 imposes no such restraint and can tolerate significant misalignment without losing resolution, thus shortening set-up time.

The Straightness Interferometer consists of a special beam-splitting prism which is insensitive to misalignment. As long as it is positioned approximately on the centerline of the laser beam, then its face only needs to be aligned to within one to two degrees of the normal to the axis of the beam.

Excessive interferometer misalignment would be denoted by a low beam alignment meter reading and a flashing light at the Laser Display.

SPECIFICATIONS

Option 30, 31, 32 Straightness Interferometers

(Unless otherwise stated, given specifications apply to both the short and long-range versions.)

ACCURACY:
Inch: ±5 microinches/foot ± 1 count in last digit.
Metric: ± 0.4 micrometer/meter ± 2 counts in the last digit.

Note: This accuracy can be improved to the limit of linearity by rotating the Straightness Reflector through 180 degrees and making a second pass (equivalent to reversal of a straightedge).

LINEARITY:
Inch: ± 1 count in last digit.
Metric: ± 2 counts in last digit.

CALIBRATION:
Short Range: ± 5% of reading.
Long Range: ± 10% of reading.

Note: The actual calibration value is marked on each Straightness Reflector.

RESOLUTION:
Short Range: As for 5526A Laser/Display (page 3).
Long Range: One-tenth that of the Short-Range version; e.g., in the X10 Mode, Metric units, the last digit has a value of 0.1 micrometer; in the NORMAL mode, Inch units, the last digit has a value of 0.0001 inch.

AXIAL RANGE:
Short Range: 10 feet (3 m) ± 5%.
Long Range: 100 feet (30 m) ± 10%.

Note: The minimum distance between the Straightness Interferometer and the Straightness Reflector at which measurements can be made are:
Short Range: 4 inches (100 mm)
Long Range: 3 feet (1 m)

DIMENSIONS:
See back page.

WEIGHTS:
10579A: Straightness Adaptor 1.0 lb. (0, 45 Kg)
Resolution Extender 1.8 lb. (0,82 Kg)
10690A: Straightness Reflector 3.5 lb. (1,63 Kg)
Straightness Interferometer 0.5 lb. (0,23 Kg)
10691A: Straightness Reflector 3.5 lb. (1,63 Kg)
Straightness Interferometer 0.5 lb. (0,23 Kg)

Option 33 Pentaprism

Contact Hewlett-Packard for specifications and prices.

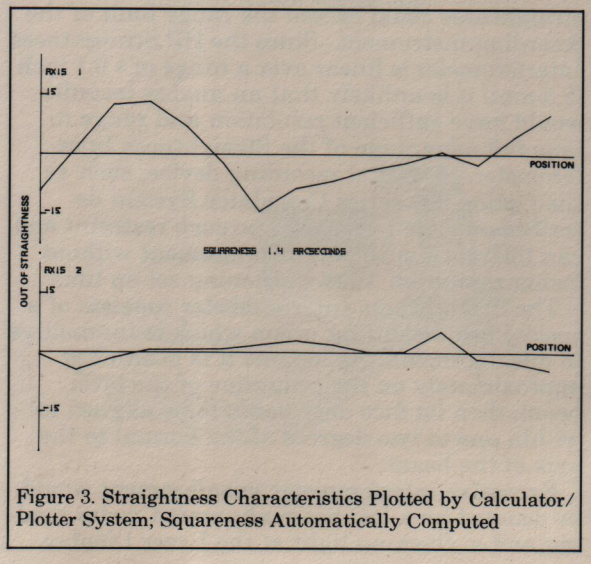
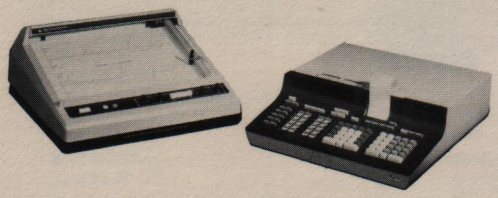


Figure 3. Straightness Characteristics Plotted by Calculator/Plotter System; Squareness Automatically Computed



CALCULATOR/PLOTTER SYSTEM

Option 200 Series: Calculator/Plotter Systems

The effectiveness of the Option 30 series Straightness Interferometer can be greatly enhanced by the addition of one of the Option 200 series Calculator/Plotter Systems. This includes a specially-developed set of metrology applications programs, one of which computes and plots straightness, parallelism, and squareness profiles as well as reducing data processing and plotting times to a few seconds. The Calculator system eliminates errors and reduces set-up time by transferring the measurement data directly from the Laser Display to the Calculator at each measurement point. This assures that the recorded data is exactly that generated by the Laser Display. And since normalized straightness data is computed at the end of each run, anomalies are readily visible and can be eliminated by repeating the measurement traverse.

Set-up time can be reduced since the Calculator allows much greater leeway than analog recording instruments for misalignment between the axis of the Straightness Interferometer and the axis of the machine. Thus the high linearity of the Laser Interferometer can be used to full advantage.

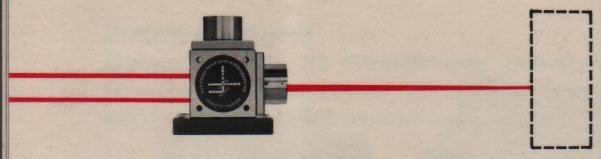
No knowledge of calculator programming is required to operate the system. The metrology program package has been prepared for the QC technician and can be run simply by following the step-by-step operating instructions.

Within seconds of completing the traverse of a machine axis with the Straightness Interferometer a plot such as that shown in Figure 3 will be automatically drawn. The X-axis of the graph can be chosen to be either the least-squares best-fit to the data, or the line joining the end points. If parallelism or squareness is to be checked, then a second adjacent axis can be measured in the same manner with its profile being plotted below the first. Squareness or parallelism error will be computed and printed out.

The same program permits the repetition of as many runs as required so that the final plot and determination of squareness or parallelism can be based on an average of all runs.

The package of programs included with the Option 200 series Systems also covers surface plate calibration, positioning error plotting, machine tool repeatability analysis, large angle corrections (for use with HP Angular Interferometer) and wavelength compensation factor determination.

For more information on the Calculator System and the Metrology Program Package ask your local Hewlett-Packard representative for literature on the Model 5526A Option 200.



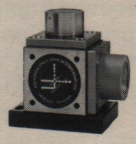
Single Beam Interferometer

Plane Reflecting Surface

SINGLE BEAM MEASUREMENTS (INCLUDING NON-CONTACT)
Option 40: Single Beam Interferometer

For those applications where the mass or size of a cube-corner retroreflector precludes the use of the 10565B Remote Interferometer the Single Beam Interferometer offers many benefits. Since the Single Beam Interferometer can determine displacement information from a light beam reflected back on itself, it can measure the displacement of any plane reflective surface with suitable flatness, surface finish and reflectivity properties. The reference beam in the Single Beam Interferometer is reflected back onto itself from the apex of the cube-corner.

To ease the constraints imposed on the surface whose displacement is being measured the beam can be focused down to a small spot. Displacement within a short range on either side of the focal length of the particular lens used can then be measured for surfaces which are not necessarily flat. This is the "cat's-eye" principle. The K08-10565A Non-Contact Lens Kit is available separately for this purpose and includes three mounted lenses with focal lengths of 5, 10 and 30 inches (130, 255 and 760 mm).



SPECIFICATIONS
Option 40 Single Beam Interferometer (K03-10565A)

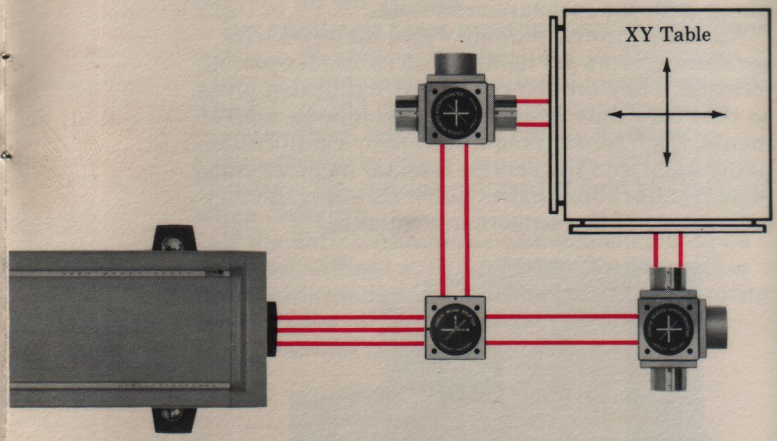
Accuracy and Resolution are as for Option 10.
REFLECTOR REQUIREMENTS (without focusing optics):
Flatness: Must not deviate from a best-fit plane by more then 10 microinches over the 0.3 inch (7mm) diameter area being used.
Surface Finish: Metal 0.1—0.3 microinch arithmetic average. Optical 80 — 40.
Maximum Misalignment to Beam Axis: ±5 arc-seconds in each of two orthogonally related axes.
DIMENSIONS: Same as 10565B Remote Interferometer
WEIGHT: K03-10565A Single Beam Interferometer 2.7 lb (1,1 Kg)

K08-10565A Non-Contact Conversion Kit

Focal Length	5 in. (127 mm)	10 in. (254 mm)	30 in. (762 mm)
Spot Diameter	0.0004 in. (0,01 mm)	0.008 in. (0,02 mm)	0.024 in. (0,06 mm)
Displacement Range	0.040 in. (1,0 mm)	0.200 in. (4,0 mm)	1.500 in. (38,0 mm)

DIMENSIONS: Same as for 10581A Plane Mirror Converter
WEIGHT: 0.5 lb (0,22 Kg) per lens.

Second-Axis Display



Typical Two-axis Arrangement (Plane Mirror Interferometers)

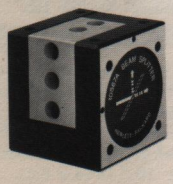
TWO AXIS MEASUREMENTS
Option 11: Second Axis Add-On
Option 13: Second Axis Add-On (Plane Mirror)

These options add a second Interferometer, a Beam Splitter and a second Laser Display. At the rear of the 5500C Laser Head there are two Display interface connectors, either of which can be used for single channel interferometry, but which are connected to two separate Laser Displays for two-axis measurements.

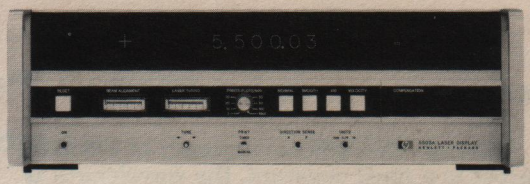
The Model 10567A Beam Splitter splits the outgoing laser beam into two paths at right angles to each other which go to the interferometers. The return beams containing the measurement information are directed back to two separate photodetectors in the Laser Head. The cubical configuration of the Beam Splitter makes for easy installation in machine tools or measuring machines for digital readout or closed-loop control applications. It also interfaces readily with the Remote Interferometer for making Pitch/Yaw versus Distance, or Straightness versus Distance measurements.

SPECIFICATIONS (10567A Beam Splitter)

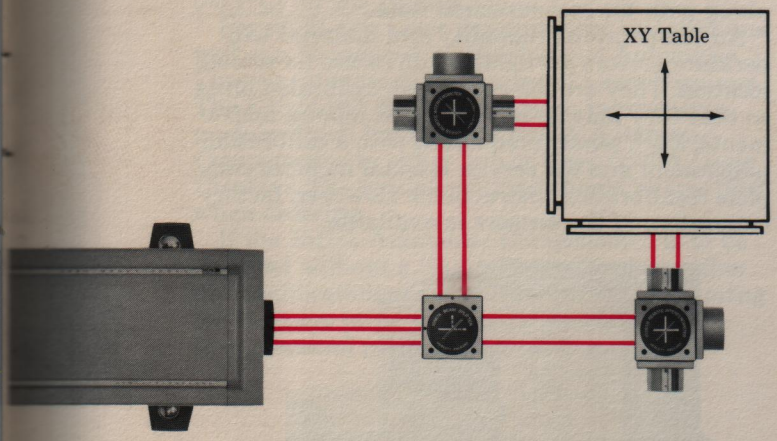
DIMENSIONS: See back page.
WEIGHT: 0.9 lb (0,4 Kg)



Second-Axis Display



5505A Laser Display



Typical Two-axis Arrangement
(Plane Mirror Interferometers)

TWO AXIS MEASUREMENTS
Option 11: Second Axis Add-On
Option 13: Second Axis Add-On (Plane Mirror)

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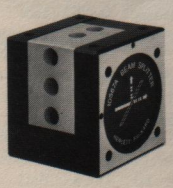
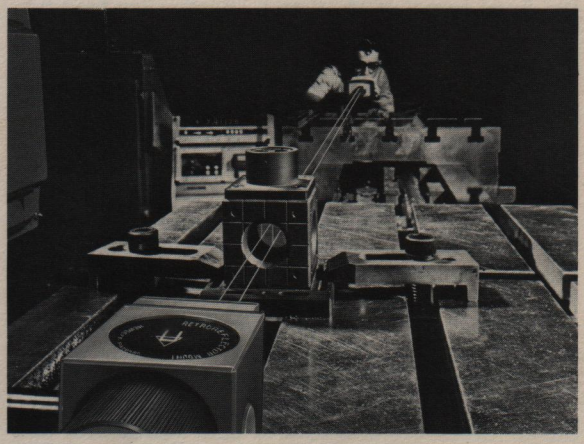
SPECIFICATIONS (10567A Beam Splitter)

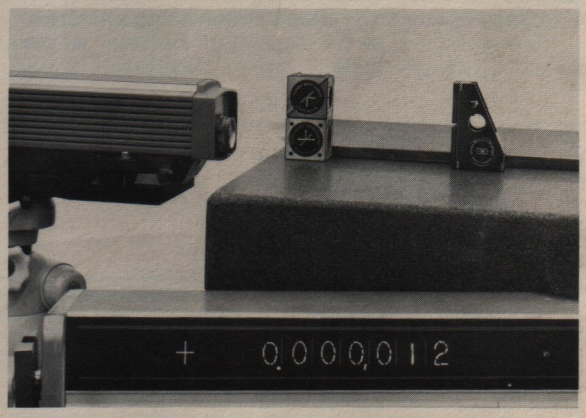
DIMENSIONS: See back page.
WEIGHT: 0.9 lb (0,4 Kg)



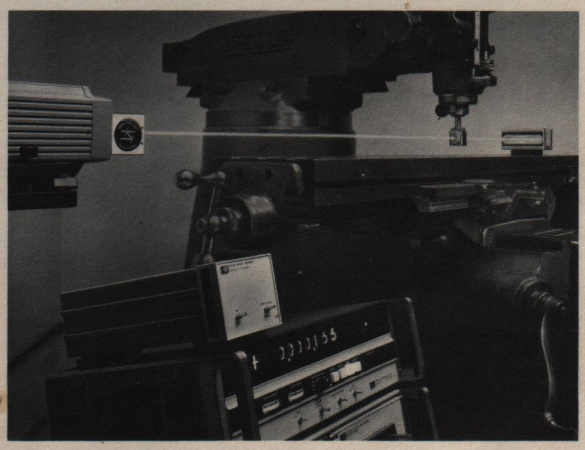
Typical Measurements with the 5526A Laser Measurement System



Length



Flatness



Straightness

5510A AUTOMATIC COMPENSATOR

Although the optical frequency of the laser output is a fixed constant, the wavelength is constant only in a vacuum. In air the wavelength decreases as the refractive index increases, and since the refractive index is affected by air temperature, pressure and humidity some facility for making corrections is required for laser interferometers.

The HP Laser Measurement System offers the choice between manual and automatic compensation. Thumbwheel switches are provided on the front panel of the Laser Display for feeding in a composite factor derived from tables or a slide chart (included with the Model 5526A).

The Model 5510A Automatic Compensator takes over this function completely. It is equipped with rugged sensors to measure air temperature, pressure and humidity and provides accurate, continuous corrections to the Laser Display. In addition it includes up to three probes for monitoring machine or workpiece temperature so that dimensions are always corrected to 20°C, regardless of the temperature during measurement. All that is required of the operator is the dialing in of the thermal coefficient of expansion of the material before taking measurements.

As well as being extremely simple to operate the 5510A offers unmatched user confidence as a result of on-line sensor read-out. The reading of any sensor may be read-out at the Laser Display, even while the measurement is in progress if required, since the displacement information is still being up-dated internally. With the Option 007 Printer connected all sensor and compensation values can be sequentially printed automatically. This SCAN feature is particularly useful for making a record of conditions along with the measurement data.

Air temperature, humidity and material temperature sensors are mounted on cables for remote location. They are self-contained, calibrated units so that they may be interchanged among instruments. Each sensor is equipped with a calibration adjustment and the service manual includes complete recalibration instructions. However, factory calibration of the sensors is available.

5510A Automatic Compensator

Since material temperature correction has the largest potential effect on measurement accuracy a special higher accuracy material temperature sensor is available either with the 5510A or

5510A SPECIFICATIONS

AIR:

Sensor	Accuracy	Range	Contribution to Laser Interferometer Accuracy
Temperature	±0.2°F (±0.1°C)	55–105°F (13–40°C)	±0.2 ppm
Pressure	±0.03 in. Hg (0.75 mm Hg)	22–31 in. Hg (560–790 mm Hg)	±0.5 ppm
Humidity	±10%RH	10–100% RH	±0.1 ppm for air temp. of 68–85°F (20–30°C) ±0.3 ppm for air temp. of 55–105°F (13–40°C)
Total Additional Measurement Error (worst case only)			±0.8 ppm, T_a = 68–85°F (20–30°C) ±1.0 ppm, T_a = 55–105°F (13–40°C)

5526A/5510A System Accuracy (worst case only):
1. For air temperature within range 68–85°F (20–30°C):
   Inch Units: ±1.3 ppm ±1 count in last digit
   Metric Units: ±1.3 ppm ±2 counts in last digit
2. For air temperature within range 55–105°F (13–40°C):
   Inch Units: ±1.5 ppm ±1 count in last digit
   Metric Units: ±1.5 ppm ±2 counts in last digit

MATERIAL TEMPERATURE: Thermistor type. Mounted in remote, oil-immersible "button" with magnetic base. One supplied with 5510A. Rear panel connectors for three. Cable length 15 feet.

Accuracy:

Range	Maximum Sensor Error	Additional Measurement Error
55–105°F (13–40°C)	±0.2°F (±0.1°C)	Depends on material coefficient of expansion

GENERAL

Total Compensation Factor Range: ±700 ppm
Warning light indicates out of range condition.
Coefficient of Expansion Range: ±29.9 ppm/°F or °C
Sensor Read-Out (with 5505A Laser Display or K15-5510A Power Supply/Display): All sensor values (in English or Metric units), and compensation numbers with and without material component. In SCAN mode all parameters are read out at 2 per second.
Environmental (operating):
Temperature: 32–130°F (0–55°C)
Humidity: 0–95% RH
Vibration: 0.010 in. peak-to-peak at 10–55 Hz for 15 min. on each axis.
Power Requirement: Power is supplied by 5505A Laser Display via connector cable.
Dimensions: 6¼ in. high, 7¾ in. wide, 11 in. deep (159 mm x 197 mm x 280 mm) without sensors. With sensors connected depth is increased by 3 in. (76 mm).
Weight: 10.8 lb (4.9 Kg).

as a separate accessory. The H05-5510A substitutes the H01-10563A version of the Material Temperature Sensor for the standard Model 10563A. Accuracy of the H01-10563A is ±0.05°F (±0.028°C) over a reduced range, compared with ±0.2°F (±0.1°C) for the 10563A.

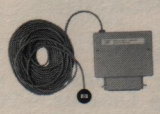
For multi-axis laser measurement installations cost can be reduced by sharing one Automatic Compensator among a number of Laser Displays. The K15-5510A Multiplexer is an inexpensive module which interfaces a 5510A Automatic Compensator to either two or three 5505A Laser Displays. The version required should be specified when ordering.

If the 5510A Automatic Compensator is to be operated without a 5505A Laser Display, either for recalibration or for environmental monitoring for purposes other than laser interferometry, then a special power supply with a four-digit

K11-5510A
Power Supply/
Display

decimal read-out, the K11-5510A, is available. It is a compact module which includes a BCD output connector for interfacing to printers or to data-processing devices. Ask for the data sheet on the K11-5510A for more details.

ACCESSORIES AND OPTIONS



1. 10563A Additional Material Temperature Sensor
   SPECIFICATIONS:
   See Material Temperature under 5510A Specifications.
2. H05-5510A Automatic Compensator with High Accuracy Material Temperature Sensor.
   SPECIFICATIONS: As for standard Model 5510A except for Material Temperature Sensor:

Range	Maximum Sensor Error
66–76°F (19.0 — 24.5°C)	±0.05°F (±0.028°C)

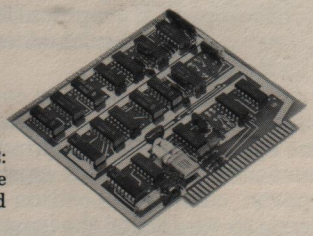
3. H01-10563A Additional High Accuracy Material Temperature Sensor.
   SPECIFICATIONS: As standard except for changes noted for H05-5510A.
4. K15–5510A Multiplexer
   SPECIFICATIONS:
   Number of channels: 2 or 3 (specify on order)
   Dimensions: 6.25 in. high x 7.75 in. wide x 11 in. deep (159 mm x 197 mm x 280 mm)
   Weight: 4.5 lb (2,0 Kg)
5. K11-5510A Power Supply/Display
   SPECIFICATIONS:
   Readout: 4 digit with decimal point English and Metric units annunciation.
   Output: BCD 1248 positive true logic at rear-panel 50-pin Blue Ribbon connector.
   Power Requirement: 115/230V ±10%, 50–60 Hz, 25 watts (with 5510A connected).
   Dimensions: 6¼ in. high, 7¾ in. wide, 11 in. deep. (159 mm x 197 mm x 280 mm)
   Weight: 6.5 lb. (3 Kg).

OUTPUT OPTIONS

Option No.	Description
5526A — 002	Pulse/Quadrature Output
5526A — 003	Resolution Extender
5526A — 004	Error Plotting Output
5526A — 005	Error Plotting System (Inch Calibration)
5526A — 006	Error Plotting System (Metric Calibration)
5526A — 007	Printer

OPTION 002: PULSE/QUADRATURE OUTPUT

This option consists of an additional circuit board which plugs into the Laser Display. It provides either quadrature output similar to that of DC, single-frequency laser interferometers, or direct up-count and down-count pulses. Yet all the advantages of two-frequency interferometry are retained. Either quadrature or pulse operation can be selected by jumper wires on the circuit board. Resolution is one quarter wavelength



Option 002:
Pulse/Quadrature
Output Board

(approximately 6 microinch or 0.16 μ). The pulse-doubled mode (selectable by circuit board jumper wires) generates two pulses for each quarter-wavelength displacement, making for compatibility with eighth-wavelength resolution controllers. Noise-free and jitter-free output signals are guaranteed by the use of digital hysteresis.

SPECIFICATIONS

RESOLUTION: 1/4 wavelength
MAXIMUM SLEW RATE: 12 in/sec or 18m/min. (In pulse-doubled mode the slew rate limit is cut to 8 in/sec or 12 m/min.).
OUTPUT: TTL output stage capable of supplying 2.1 volts into 50 ohms. Square wave A-Quad-B, or pulses of 40 nsec duration.
COUNTER: Minimum input bandwidth requirement is 12.6 MHz (4.2 MHz in pulse-doubled mode).

OPTION 003: RESOLUTION EXTENDER

Hewlett-Packard's two-frequency AC interferometer principle lends itself to a form of real-time resolution extension which is not feasible with conventional interferometers. The Resolution Extender is a small module which is inserted in the cable between the Laser Head and the Display. Resolution multiplication is effected by multiplying the Doppler frequency difference by the desired factor. Option 003 can be wired for a resolution extension factor of 6, 7, 8, 9 or 10.

With the extender inserted, the display operates normally in all modes including X10 and velocity, except that all displayed readings must be divided by the resolution extension factor.

In addition to the extra high resolution available with this device, another major benefit is that it enables the user to combine the high update rate of the NORMAL mode of operation with the high resolution of the X10 mode since the update rate of the NORMAL mode remains unchanged when the resolution extender is switched into the system. This is of particular value in closed-loop applications.

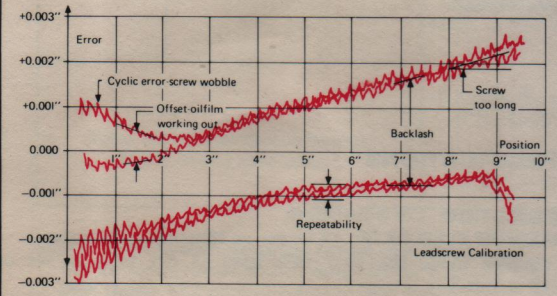
SPECIFICATIONS

PLUG-IN OPTION: Requires no modification to 5526A System. Connects between 5500C Laser Head and 5505A Display. Power is supplied by 5505A.
SPECIFICATIONS: Maintains all specifications of 5526A except for:
Resolution: In standard form all modes of operation are divided by a factor of 10. The configuration of circuit board jumper wires can be changed to give factors of 6, 7, 8 or 9.
Max. Measuring Velocity: 2 in/sec (3m/min) with 6X resolution; 1 in/sec (1,5 m/min) with 10X resolution.
SWITCHING: A single switch restores normal (X1) operation without disconnecting the Resolution Extender unit. Zero reference (reset) must be re-established after switching.
TERMINALS:
Input: 18 pin connector for cable from 5500C.
Output: 18 pin connector for cable to 5505A. Both on front panel.
WEIGHT: 2 lb. (0,9 Kg)
SIZE: 1½ in. high x 5⅛ in. wide x 6 in. deep (3.8 x 13 x 15.1 cm)

OPTION 004: ERROR PLOTTING OUTPUT

This option provides an inexpensive method of graphically recording positioning errors as a function of command position, during the calibration traverse, without any external computational device. Downtime is minimized and external data processing is eliminated. With the error information in graphical form, wear patterns, cyclic errors, and other characteristics can be readily distinguished.

Upon receipt of a pulse or contact closure, generated within the Laser Display, or provided by the operator or the machine being calibrated, the measurement value is sampled and split into two parts: command position (significant digits) and error (contained in the least significant digits). The assumption is made that maximum error does not exceed more than half the minimum calibration interval. This interval is constrained to be an integral multiple of 0.010 in. (0,1 mm) in the NORMAL mode and 0.001 in. (0,01 mm) in the X10 mode.



Two out and back (top and bottom) error plots of a milling machine leadscrew clearly show the various sources of error.

The error and command values are outputted in analog form at two rear panel terminals for connection to an XY recorder (included in Option 005 and 006).

SPECIFICATIONS

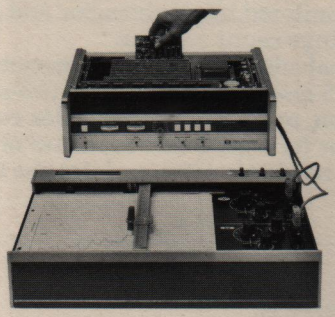
ACCURACY:
Digital: ±5 parts in 10^7 ±1 count in last digit.
Analog: Linearity ±0.5%. Offset ±10 mV (can be adjusted out with zero offset control of X-Y Recorder.
Analog Time Constants: X-axis: 470 msec; Y-axis: 34 msec
RESOLUTION:
Normal Mode: 0.000,01 in. (0.000,1 mm).
X10 Mode: 0.000,001 in. (0.000,01 mm).
RANGE:
X-axis (Single Pass):
Normal Mode: 100 in. (1000 mm)
X10 Mode: 10 in. (100 mm)
Calibration traverses in excess of these ranges can be made in stages. At the end of each stage the X-axis output will return to zero.
Y-axis (Error Amplitude):
Normal Mode: ±0.005 in. (±0.05 mm)
X10 Mode: ±0.0005 in. (±0.005 mm)

CALIBRATION INTERVAL:
Any Integral Multiple of:
Normal Mode: 0.010 in. (0.1 mm)
X10 Mode: 0.001 in. (0.01 mm)
OUTPUT:
Full Scale Voltages:
X-axis: 10V
Y-axis: ±5V
Available at two rear-panel BNC connectors
PLOTTING ACTUATION:
By means of one of three methods:
1. **Manual:** by 5505A front-panel MANUAL PRINT switch;
2. **Automatic:** external actuation by means of either:
   a. Contact closure to ground, or
   b. TTL open collector input. Minimum pulse width 0.2 μsec. Minimum pulse spacing 30 msec.
3. **Internal timing by means of built-in time-base:** Front panel switch sets stepping rate. Contact closure connectors available at rear panel to control machine advance.

OPTIONS 005 AND 006: ERROR PLOTTING SYSTEM (INCH & METRIC CALIBRATIONS)

This option includes the Option 004 Error Plotting Output board and cables, and also includes the HP Model 7035B X-Y Recorder. This recorder is a high performance, low cost instrument which has established a reputation for reliability. It is very simple to use, and features electrostatic paper hold-down, solid state circuitry, electric pen lift and five calibrated ranges in each axis. The platen size is 8½ in. x 11 in.

For specifications and a more detailed description please ask for a Model 7035B data sheet.



OPTION 007: PRINTER

This printer is a slightly modified version of the HP 5055A Digital Recorder. This is a highly reliable, compact and well proven instrument which can provide a printout of the Laser Display reading at up to 10 lines per second. Either regular or pressure-sensitive paper can be used. For ink printing, a continuously rotating ink roller is included.

The cabinet size of the Option 007 Printer matches that of the Model 5510A Automatic Compensator so that both instruments may be mounted in a single combining case as shown in the picture.

For more detailed information and specifications please ask for HP 5055A Digital Recorder data sheet.

OTHER ACCESSORY EQUIPMENT

10551A	Beam Bender/Alignment Mirror
10560A	Barometer/Thermometer Kit
10580A	Laser Tripod
10634A	Storage Case for Linear Interferometer
10635A	Storage Case for Linear/Angular Interferometer
9211-1587	Transit Case for 5500C
9211-1587	Transit Case for 5505A
9211-1738	Transit Case for 5510A or 5055A

10560A BAROMETER/THERMOMETER KIT

For manual compensation of the Model 5526A the 10560A Kit offers economical and accurate instrumentation. The kit includes an aneroid barometer and two dial type thermometers. Both instruments have scales in English and Metric units.

10551A BEAM BENDER/ALIGNMENT MIRROR

This accessory is an extremely versatile tool for aligning and deflecting the laser beam of the 5500 series Laser Heads. The basic element is a high quality mirror, coated to reflect most efficiently at 6328Å. It is mounted on a hardened, cast steel base of ingenious design. Precision ground surfaces enable a user to align the plane of the mirror either perpendicular to, or at 45° to, any reference plane to within 1 minute of arc.

Beam alignment of the laser interferometer is greatly eased with this accessory. By dialing in two of the reference surfaces the mirror can be aligned perpendicular to the axis of measurement. Adjustment of the laser head for beam alignment is then a simple matter.

SPECIFICATIONS

ACCURACY:
Mirror Alignment:
Perpendicular and parallel to base and sides to within ±1 minute.
Alignment Surfaces: ±1 minute.
DIMENSIONS: See back page.
WEIGHT: 3 lb. (1,4 Kg)

10580A LASER TRIPOD

All the interferometers in the Laser Measurement System are remotely locatable for greater accuracy and easier fixturing. To take full advantage of these benefits the Laser Head should be mounted away from the measurement setup. The Model 10580A Laser Tripod is designed especially for this purpose, offering significant benefits of easier setup and more rapid alignment. A kinematic mounting plate, equipped with quick release clamps, can be adjusted for height, rotation, and lateral position. Tilt adjustment is by the rear foot of the Laser Head itself. The tripod is collapsible and portable, yet covers a wide height range, from 32½ inches (825 mm) to 64¾ inches (1640 mm).

SPECIFICATIONS

DIMENSIONS: See back page.
WEIGHT (net): 31 lb. (14 Kg)

PRINCIPLE OF OPERATION

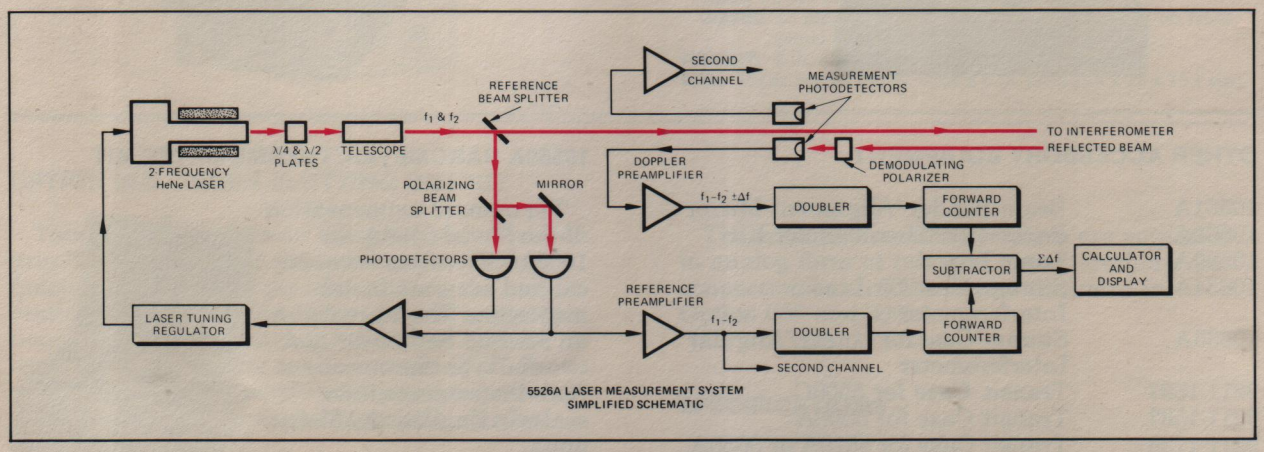
General

A low-power helium-neon laser emits a coherent light beam composed of two slightly different optical frequencies, f_1 and f_2, of opposite circular polarizations. After conversion to orthogonal linear polarizations the beam is expanded and collimated, then directed to the reference beam-splitter where a small fraction of both frequencies is split off.

This portion of the beam is used both to generate a reference frequency and to provide an error signal to the laser cavity tuning system. The difference in the DC levels of f_1 and f_2 is used for tuning while the AC component of the difference between f_1 and f_2 (about 1.8 MHz) is used for reference and goes to a counter in the Laser Display.

The major portion of the beam passes out of the Laser Head to an interferometer. All HP interferometers measure relative displacement of two retroreflectors by splitting the beam into f_1 and f_2, directing them to two retroreflectors, and returning the resultant signals to a photodetector in the Laser Head. Relative motion between the retroreflectors causes a difference in the Doppler shifts in the return frequencies, thus creating a difference between the frequency seen by the measurement photodetector and that seen by the reference photodetector. This difference is monitored by a subtractor and accumulated in a fringe-count register.

A digital calculator samples the accumulated value every 5 msec and performs a two-stage multiplication, one for refractive index correction and the other for conversion to inches or millimeters. The resulting value updates the display.

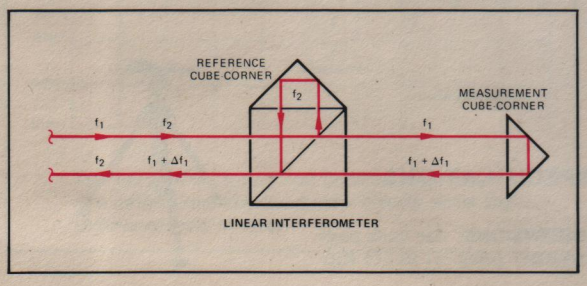


5526A LASER MEASUREMENT SYSTEM
SIMPLIFIED SCHEMATIC

INTERFEROMETERS

Linear

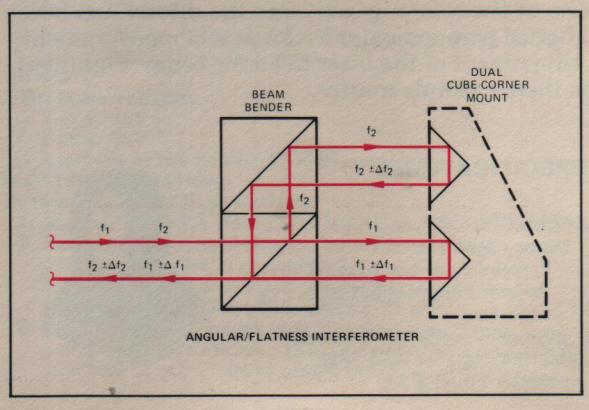
The beam exiting from the Laser Head is split at the surface of a polarizing beam-splitter, with one frequency reflected to the reference cube-corner mounted on the housing. The other frequency is transmitted to the measurement retroreflector. Both frequencies are reflected back along a common axis to the photodetector block in the Laser Head, one of which includes a Doppler frequency shift whenever the measurement retroreflector moves. Since their polarizations are orthogonal to each other, they do not interfere to form fringes until the beam reaches the demodulating polarizer mounted in front of the photodetector.



LINEAR INTERFEROMETER

Angular/Flatness

A 45° mirror is mounted in place of the reference retroreflector so that f_1 and f_2 are sent out parallel. Angular displacement of the retroreflector mount causes a differential Doppler shift in the returned frequencies which is not affected by axial displacement. The accumulated fringe counts are proportional to the sine of the angular displacement.

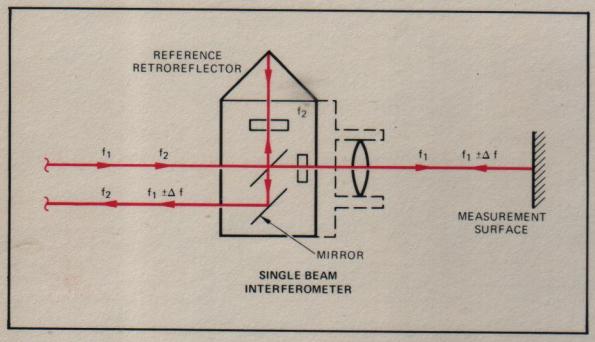


ANGULAR/FLATNESS INTERFEROMETER

INTERFEROMETERS (Cont'd)

Single Beam Interferometer

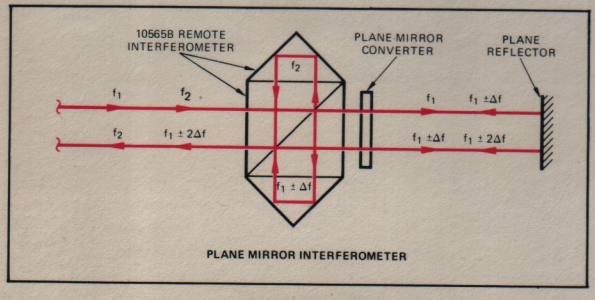
A polarizing beam-splitter reflects f_2 to the reference retroreflector and transmits f_1 to the surface whose displacement is being measured. Since both beams leaving the beam-splitter pass through a quarter-waveplate the returning polarizations are rotated through 90°. This causes f_2 to be transmitted and $f_1 \pm \Delta f$ to be reflected so that they are returned coaxially to the Laser Head by the beam-bending mirror.



Plane Mirror Interferometer

The beam entering the interferometer is split into f_1 and f_2, with f_2 returning to the Laser Head after retroreflection by the reference cube-corner, as in the Linear Interferometer. f_1 is transmitted out to the plane reflector and is reflected back on itself. The Converter causes the polarization of the return frequency to be rotated through 90° so that $f_1 \pm \Delta f$ is reflected out a second time where it is Doppler shifted again. The polarization of $f_1 \pm 2\Delta f$ is rotated again through 90° so it is now transmitted back to the photodetector. Resolution doubling is inherent because of the double Doppler shift but the H03-5505A Laser Display is modified to remove the doubler in the output from the Doppler preamplifier, thus correcting the displayed resolution

Any tilting of the plane reflector relative to the beam axis results only in an offset of the return, not in a tilt, since tilting of the reflected beams is exactly compensated by the second reflection.

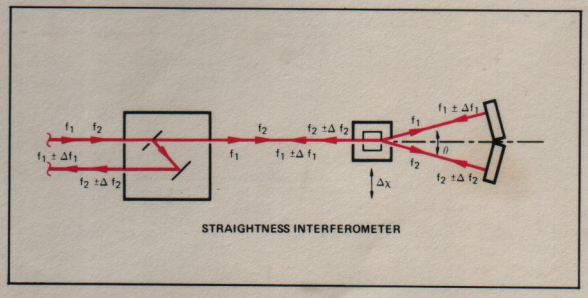


Straightness Interferometer

The two-frequency beam exiting from the Laser Head is transmitted through the Wollaston prism interferometer. Because the composite refractive index of the prism is different for the two planes of polarization which distinguish F1 and F2, F1 and F2 exit with a small included angle.

They are reflected back by two plane mirrors rigidly mounted at an included angle precisely matched to that of the Wollaston prism interferometer. F1 and F2 therefore recombine within the prism. The combined beam is returned coaxially with the exit beam to the partial mirror in the Straightness Adaptor. The majority of this returning signal is reflected down to a mirror which reflects the return beam back into the lower aperture of the Laser Head and thus to a demodulating polarizer and photodetector.

The interferometer measures relative lateral displacement between the interferometer and the reflecting mirror axis. Whether the measurement will be in a horizontal or vertical plane depends on the orientation of the mirrors and the prism within its mount.

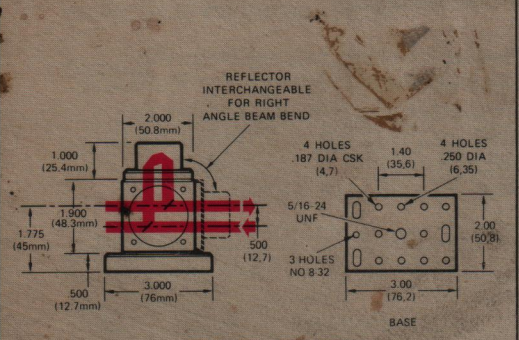


Relative lateral displacement between the prism and the mirrors affects the difference in optical path lengths between the two beams causing a difference in accumulated fringe counts. Movement of the mirror assembly with respect to the beams causes a lengthening in the beam from the side to which the mirror assembly moves, and a shortening on the opposite beam. For movement of the interferometer with respect to the axis of the mirror assembly, there is an optical path length change within the prism proportional to the difference in the refractive indices specific to each plane of polarization. In either case, for a relative lateral translation x the fringe counts accumulated will be given by $2x \sin \theta/2$, where is the included angle between the beams. However, if the beam moves with respect to the mirror axis any path length change in the air space is balanced by a compensating optical path length difference within the prism. Thus the device is insensitive to spatial deviations of the laser beam.

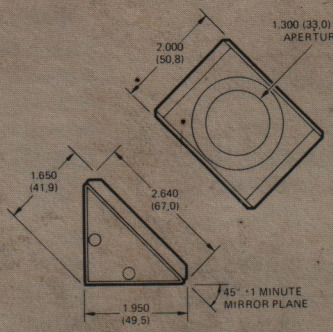
Small pitch, yaw, or roll motions of the Interferometer do not create a path difference and therefore do not affect the measurement accuracy.

To give a correct readout at the display, the fringe counts must be multiplied by the reciprocal of $2 \sin \theta/2$, which for the value of θ used is 36. An electronic Resolution Extender is included to take care of this. θ is about 1-1/2 degrees for the Short-range Interferometer, and one tenth that for the Long-range version.

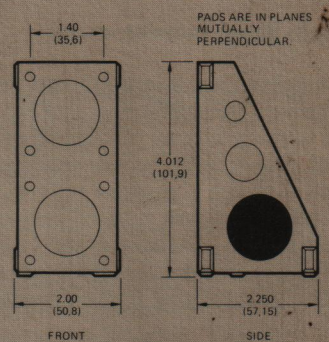
DIMENSIONS



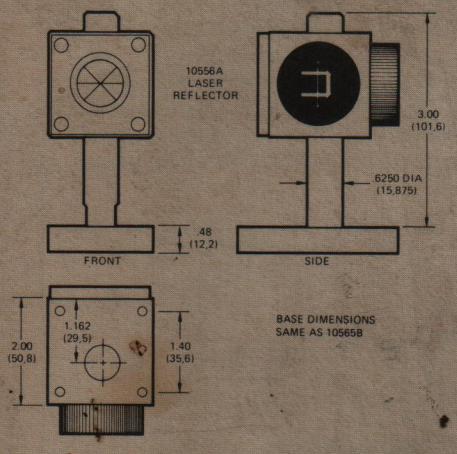
10565B REMOTE INTERFEROMETER



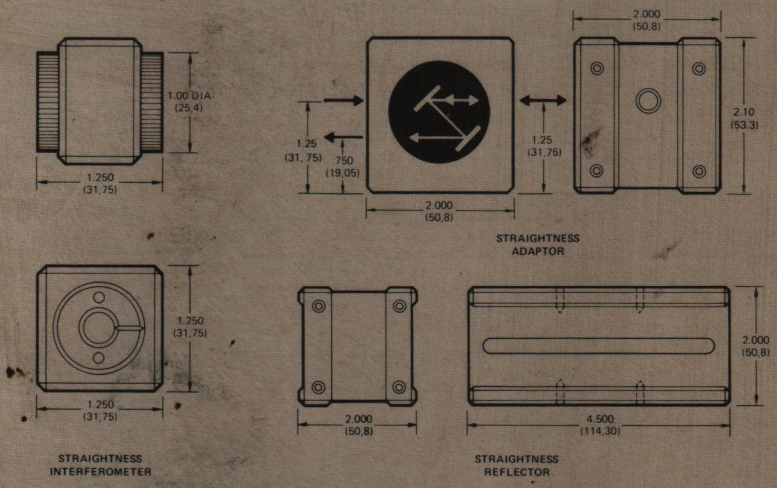
10557A TURNING MIRROR



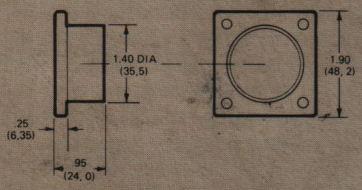
10559A REFLECTOR MOUNT



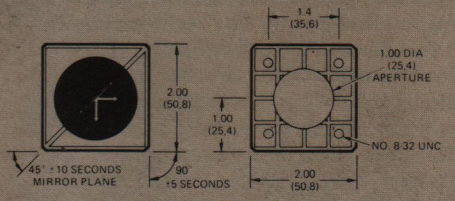
10550B LASER REFLECTOR AND MOUNT



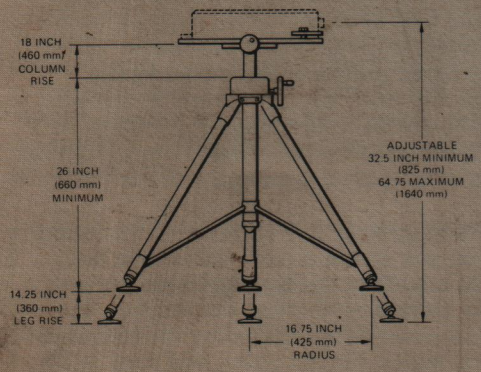
5526A OPTION 30 STRAIGHTNESS INTERFEROMETER



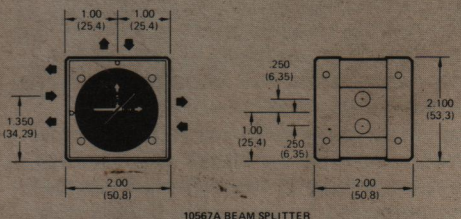
10581A PLANE MIRROR CONVERTER



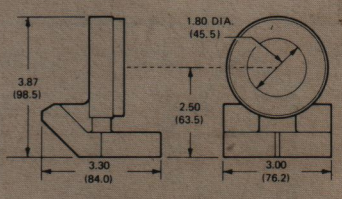
10558A BEAM BENDER



10580 LASER TRIPOD



10567A BEAM SPLITTER



10551A BEAM BENDER

For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181 • West (213) 877-1282. Or, write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, Post Office Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan, Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

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